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THE MATHEMATICS TEACHER

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EDITORIAL.

Mathematics Teachers using the Slide Rule

The use of the slide rule in mathematics classes is rapidly increasing. One school of a technical nature reports that every student in the first term is taught the use of the rule. In the Stuyvesant Evening Trade School of New York City, it is found that attendance is better during the teaching of the slide rule than at any other time during the term. A young woman who is private secretary to the president of a large electrical company uses the rule constantly and finds that it saves two-thirds of her time in checking office work. In the review courses of the Junior High School based on the real problem the slide rule is being found useful. In every academic high school there should be a course in review mathematics, preferably in the senior year. The slide rule introduced early in this course will prove fascinating to the students and will abridge many tedious mathematical calculations. A student applying for a position and equipped with a knowledge of the slide rule is often preferred before other candidates.

The principle of operation may be easily explained to a class in five minutes in sufficient detail to satisfy the students that it is reasonable. To obtain sufficient practice an hour per day for a week or two is usually necessary.

In the past, two things have hindered the teaching of the slide rule,—ignorance of teachers regarding it and the expense of equipment. Now, however, there are several good treatises

with abundant examples and numerous illustrations which make it perfectly possible for a mathematics teacher to instruct himself in the use of the rule. Expense, also, has been reduced to a minimum, so that a very good rule can be secured for $2 or $2.50.

THE MATHEMATICS TEACHER is glad to encourage the further extension of the use of the slide rule among teachers of mathematics. To this end inquiries regarding material and courses will receive prompt attention. W. E. B.

MATHEMATICS AND PSYCHOLOGY.

By C. C. Grove.

(*Continued from page 182, Vol. VIII.*)

PART II.

The Mathematics of Psychologists and the Validity of their Uses of its Forms and Processes.

Above we pointed out in rather homiletic form an attitude toward the attacks upon the disciplinary value of mathematics and indicated the proper reaction of teachers of mathematics to those attacks. Herein we proceed to sketch the attempts at "mental measurement," to ascertain what was and is being measured, to investigate the fundamental assumptions made in the development of the statistical methods employed in the investigations on the transfer of mathematical training and to what classes of data we may apply methods involving the theory of probability. It is intended to give examples of classes of errors and misconceptions found in the literature, and it is hoped to be possible to make one or two helpful, constructive suggestions.

The Essentials of Mental Measurement, by William Brown, Cambridge University Press, 1911, gives an excellent, brief review of the work towards "mental measurement" up to 1911, but it is not easy reading for the layman on account of its brevity. A comprehensive historical and critical treatment may be found in *Experimental Psychology,* Vol. II, Part II, Instructors' Manual, by E. B. Titchener, The Macmillan Co., 1905. Only a scholarly layman in the field under discussion would get through any considerable portion of this book, however. A book that will bring the subject up to date, to appear during June, 1916, is *The Measurement of Intelligence,* by Lewis M. German, Houghton Mifflin Co.

You will therefore pardon the writer if he takes more time than he desires to take in simply sketching the history of the

attempts at "mental measurement." We shall consider, first, attempts at *direct measurement;* second, attempts at *indirect measurement.*

Direct Measurement.

The employment of advanced mathematics by psychologists may well be considered to date from Johann Friedrich Herbart (1776–1841), who carrying out his conception of a statics and a mechanics of mind as well as of matter wrote at Königsberg in 1822 a memoir with the lengthy title: *De Attentionis mensura causisque primariis. Psychologiae principia statica et mechanica exemplo illustraturus scripsit Joannes Fridericus Herbart, Philos. et Paedog. P. P. D. in Academia Regiomontana.*

It has been my privilege to examine possibly the only copy of this book in America, owned by Professor David Eugene Smith, who suggested and inspired the study of the present subject.

His employment of differential and integral equations to such a subject as attention was at once a daring and startling adventure. We may well imagine that this successor to Kant at Königsberg attracted much attention in university circles. Practically no one, however, has adopted his doctrine, and the memoir on attention within fifty years was entombed in De Morgan's "Budget of Paradoxes," with the statement that the thesis had not been upheld and with the expression of hope that De Morgan's mathematical readers might have better luck than he had had in interpreting the formulas if there is anything in them.

Like many another great pioneer, Herbart, could he return after seventy-five years, would likely say, "My psychology has indeed set men to work. They have recast much and cast some aside, but my work has not lost its influence." Men were awakened to the possibility of applying the forms of mathematics to psychology, although almost none venture to adopt Herbart's mathematical foundations. As James Ward has written, "We are most of all indebted to Herbart for the enormous advance psychology has been enabled to make thanks to his fruitful treatment of it. His criticisms are worth more than his constructions." His mathematics must be classed with his constructions.

During the same decade in which Herbart's *De Attentionis* was published, Ernst Heinrich Weber (1795–1878), professor

of anatomy at Leipzig, was making experiments in an attempt to give quantitative expression to the relation between physical stimuli and the resulting psychical reactions. His experiments were conducted chiefly with weights that were tested by the pressure they exerted and by lifting. He observed the differences in the lengths of lines that could be detected. In all these tests he found that in order that the sensational difference remain the same the change in the stimulus must be constantly in the same ratio to the preceding stimulus. For example, if weights of 32 and 30 ounces can just be distinguished, so can weights of 64 and 60 ounces, whereas a weight of 62 or 63 ounces could not be distinguished from one of 60 or 64 ounces. In the case of lengths the ratio was found to be about one one-hundredth, so that lines of 50 and 50.5, or of 100 and 101 inches, could be just distinguished.

The law may be stated in the words: In order to get successively just-noticeable differences in sensation, or so that the sensations increase by a common difference, the increases in the stimulus must be in geometrical progression; *i. e.*, for sensational intensities to increase in arithmetical progression the stimulus must increase in geometrical progression; or still further in the symbols of the differential calculus.

dR/R = a constant, the just-noticeable difference in sensation, dS, where R represents the value of a stimulus and dR the just-noticeable difference in stimulus.

Weber seems to have had no special absorbing interest in his findings, at least not more than in many other observations that engaged his attention. It was left for Gustav Theodor Fechner (1801–1887) to name the doctrine Weber's Law and to call Weber the Father of Psychophysics. Fechner came to the University of Leipzig in 1834 as professor of physics, just after Weber published the final report on his experiments.

Quoting from *The Essentials of Mental Measurement, l. c.*, p. 4, I add:

"Fechner verified Weber's Law in many different realms of sensation intensity, and made it the basis of his own system of mental measurement. This he did by making the following three assumptions:

"1. That a sensation intensity is a measurable magnitude and may therefore be regarded as a sum of unit intensities;

"2. That just-noticeable differences of sensation intensity are equal at different parts of the stimulus scale, and may therefore conveniently serve as the unit intensities above-mentioned;

"3. That the just-noticeable difference of sensation may be treated as a difference of two sensations, or at least that if Weber's Law applies to the former ('sensed difference') it will also apply to the latter ('difference sensation').

"On the basis of Weber's Law and these added assumptions, Fechner obtains the following formula, viz.,

$$dS = c(dR)/R,$$

which he calls the *fundamental formula for mental measurement.*" Integrating this formula, making certain assumptions as to initial values, and changing to common logarithms, the formula was expressed as $S = k \cdot \log R$. S stands for sensation intensity and R for stimulus as before.

All the assumptions are questionable and have been vigorously attacked. As to the first assumption, we observe crimson is not n times pink nor yet the nth power of pink. Fechner himself fell back on introspection to seek ground for his second assumption. His third assumption brings us to the interpretations of Weber's Law, in that we would know in what sense the relationship between "sensed difference" and "difference sensation" is given by the Law. Shall we with Fechner say it is a psychophysical law giving the fundamental relationship between body and mind? Or, shall we with Wundt interpret it as purely psychological, expressing the law of relativity of mind? Or, with Müller, Ebbinghaus, James, and others, do we believe the law is physiological and that we must study therefore the nature of nervous action?

But throughout we are positing Weber's Law, and that too in the face of the accepted fact that experiments have shown that it holds only within a limited range. As to the value of the doctrine as a whole, it may be interesting to quote Professor James, who wrote (*Psychology*, Vol. I, p. 534), concerning Fechner's book, *Elemente der Psychophysik*, "of which . . . the proper psychological outcome is just *nothing*. The psychophysical law controversy has prompted a good many series of observations on sense-discrimination, and has made discussion of them very vigorous. It has also cleared up our ideas about

the best methods of getting average results, when particular observations vary; and beyond this it has done nothing."

Finally, J. R. L. Delboeuf defined a unit of sense measurement that gave some hope. He, in arranging a series of grays, took for unit of measure the *contrast* between two shades however near or remote. As then he could select another between which and the lighter of the two chosen there was as much contrast as between the two chosen, he could get two in the scale of *contrast*, etc. Thus there was, he thought, something that could be measured in terms of a unit of the same kind, and said that "the sensation is measured by a unit of sensation." Observe that this is, however, a unit of *contrast* and *not* a unit of *sensation*. And *is contrast* a measurable quantity? If we arrange objects so that with respect to some quality each is sensibly equally contrasted with respect to the object next on its right and left, can we be said to be measuring that abstract quantity, Delboeuf's "degree of sensible contrast"?

Though a member neither of the Department of Philosophy nor of that of Psychology, the writer may perhaps be permitted to express what introspection and observation have given him as experience. In *Elements of Social Psychology*, LADD AND WOODWORTH, *Scribners*, 1911, Part Third, p. 668, we read: "In all the discussions of the previous chapter it was implied that we were dealing with two different existences—separable at least in thought, and apparently belonging to widely divergent species of existence." And again on page 687, "It knows no decisive reason against the belief that such a non-material and real unit-being, as the mind is, should exist in other relations than those which it sustains at present to the structure of the brain. On the contrary, it discloses certain phenomena which at least suggest, and perhaps confirm, the possibility of such existence for the Mind."

The writer would state that he experiences three different existences, which at some stages of their inter-relationships are difficult of distinction, as is the case with vegetable and animal life sometimes. This experience he chooses to state briefly in the words, man is a physical, a psychical, and a spiritual, being. The physical refers to the body; its training has been called physical education; the psychical has to do with the mind and we give the name education to its development; the spiritual life is

the life of faith and its realm is religion. At present we are not concerned with the latter but mention it to round out the whole of human nature.

We add that *each realm has its own standards, measures and language and these are transferable only by analogy.* Man is not in the same stage of development in these three forms of life at any time. In the last two he comes to live in that realm where time and space are no more. He still knows very little of the language of those realms. That idea, that thought, that vision of truth, what distance did it come and what length of time did it require for the journey? This light is brighter than that and physicists measure their intensities, physical properties in terms of physical units of measure, but introspection shows that the intellectual man is perceiving not *quantitatively* but *qualitatively* the sensations produced. This light hurts my eye more than that, but the sensation, the message to the brain, the consciousness of it, is not twice as great. It is a different sensation, message, consciousness. In the telephone the diaphragm is so sensitive that even the quality, the identity of the speaker's voice is recognized. The softer tones are none the less perceived than the louder, but they are perceived as softer.

Things must be discerned in their own realms. You cannot attain unto infinity by any accumulation of discrete units, however large each unit may be. Yet infinity exists between the nibs of your pen. The finite and the infinite are two different realms. Their languages are not the same and poorly transferable by analogy. You simply cannot attain unto the infinite that way.

So there are other things that cannot be done in what may seem to some a reasonable way. Yet many of the greatest things are accomplished by apparently not being concerned with those but other less important things. "Thus life succeeds in that it seems to fail." We believe that "mental tests" are not going to "measure" mentality in an individual, whatever else they may measure, much beyond what the trained judgment of the tester tells him. The physical concomitants of mental action are not readily transferable as language nor as measures to the mental functions themselves. Thus it seems inadvisable to speak of "mental measurement," for we are therein following the vulgar practice of speaking of mental and spiritual phe-

nomena in terms of the physical realm of sense and sensation. We believe the word "measurement" should be left for the physical world and that it is better to speak of "grading" or of "ranking" judgments and mental characteristics and functions. Therein we would not intend to imply that a person receiving a grade of 80 has twice as much of the quality tested as another graded 40. We would mean that at a specified time, under specific conditions, under and in the judgment of a named person conducting the test the first person did twice as much of a test given in detail as the other. That is what we mean when we grade students and we do not profess that mental abilities or intellectualities are to each other in the given ratios.

Brown, *l. c.*, p. 10, says: "The preceding account has probably sufficed to show that purely psychical measurement is a possibility. Its practical application, however, has been more detailed than extensive." A thoughtful reading of what precedes we feel convinces the reader that we cannot measure man's intellectual stature or growth with a meter bar, a liter, nor in kilograms; also that psychic phenomena though in time and space require neither time nor space in the doing. We can measure their physical concomitants, their stimuli and physical expressions, or effects, but not the psychical, in terms of the physical. *Each realm has its own standards, measures and languages and these are transferable only by analogy.*

Indirect Measurements.

In seeking for early work along the line of indirect "mental measurement" I find that at the meeting of the Anthropological Institute of Great Britain and Ireland* on November 10, 1885, the president, Sir Francis Galton, said the paper "by Mrs. Bryant gives the result of a first scientific attempt to test certain elementary characteristics in the disposition of school-children, and that by Mr. Jacobs endeavors to assign a numerical ratio to the intellectual ability of the Jews as compared to that of other races." The first of these papers has been read with interest and deserves mention because it seems to have been overlooked, because it antedates other papers given as first memoirs on the subject, and because it expresses such sound judgment and ability on the part of its author, which received most favor-

* Journal, Vol. 15, 1885–6, pp. 338 sq.

able criticism at the meeting from psychologists as well as other scientists.

Dr. Bryant's paper was written at the suggestion of Francis Galton that she "devise means of testing the mental characteristics of children." She chose the plan of having them write reports on observations made without communication at the same time, believing that "a writer tells more tales about his fundamental intellectual characteristics than a talker in close contact with another mind or other minds is likely to tell; at any rate, he tells different tales." At the outset Dr. Bryant distinguishes between "the sense impression and the apprehension of it by the mind, as between the passive and active factors of perception."

Several other quotations should be given:

"The results of a *single* test may be accidental, . . . much less importance should be attached to negative than to positive results."

"The exact numerical marks cannot be considered as at all reliable in the sense of assigning precise degrees of value, and on the whole I am inclined to think that verbal remarks would be more valuable."

"It goes without saying that the sources of error in such observations as these are very numerous. Accidental variation in the subject of the observation from time to time may produce quite misleading responses to the tests used. This is the least serious difficulty, however, since it can be dealt with, like all other similar difficulties, by taking the mean of several observations and noting at the same time the limits of variation as itself an important fact. More serious are the difficulties arising from the complex implication of mental quantities with one another, which makes it impossible to measure them separately as physical quantities are measured, or calculate them with any pretence to scientific accuracy."

Would that many more recent writers understood as clearly what may be done with "accidental errors" and did not tacitly assume that all the many sources of error are of the accidental type.

(*Continued in the next issue.*)

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VARIABLES AND LIMITS.

By Dunham Jackson.

The serious student of pure mathematics often has occasion for the uncomfortable belief that if his science is regarded with any interest at all, it is because it has ascribed to it certain qualities of doubtful merit which it does not possess. It is supposed to be in some way outside the bounds of normal human thought, and to deal with processes unintelligible to rational beings. When the mathematician is not making use of the fourth dimension to prove theorems that aren't so, he is lightly tossing infinity from one side of an equation to the other and pretending to be edified thereby. The proudest monument of mathematics is the infinitesimal calculus; and what is an infinitesimal? It is an infinitely small quantity, a quantity which is simultaneously zero and different from zero, at the same time there and not there, a thing essentially self-contradictory and intrinsically impossible. The one thing that you need, in order to be a mathematician, is an unhesitating readiness to identify truth with falsehood.

Your fellow-citizen not only comes to you with this opinion of your integrity; he resents it bitterly if you try to modify his views. He thinks you are denying everything in mathematics that is worth while. If you can't rise above the limitations of logical consistency that embarrass other people, what are you good for? You are no better than the man who called himself an astronomer, but couldn't see the moon unless it was above the horizon. A fellow-student of mine in freshman trigonometry fought valiantly against the professor's contention that an angle of 90° didn't have a tangent in quite the same sense as an ordinary angle, and when he did yield to superior authority, it was with the reservation that he thought it was awfully hard on 90°.

Why is it that mathematics is so generally misjudged, even among educated men? One important reason, I think, is this, that one of the most fundamental of mathematical notions remains in the background throughout the elementary study of the

subject. It is present, but plays so little part that it is scarcely recognized. I mean the notion of *function*, the association of two variable quantities so that a value of one corresponds to a value of the other.

The concept is so abstract that it can be really appreciated only after long familiarity with it, more familiarity than the student of a moderate amount of mathematics ever gets. And yet it is of hardly less universal importance than the idea of number itself. Most of us acquired the latter notion at such an early age that we have almost forgotten what a long and painful process it was. It was when we first tried to think of variable quantities that we were conscious of a blank in our thoughts where a meaning ought to be. How could you tell by looking at a quantity whether it was variable or not, and what made it vary, and if its very essence was uncertainty, how could you do anything with it? It is at this point that the idea of *function* begins to be a blessing. For it turns out that when you are really doing mathematics you almost never have to think of a variable by itself; you have two variables in sight at the same time, and what you are concerned with is a relation between them, a correspondence of particular values of one variable to particular values of the other. There may be more than two variables, but there are always at least two. It is not easy to say in general terms how this correspondence comes to establish itself in your mind, nor is it necessary to do so. Very few of us, if any, could give an intelligible account of what the ordinary numbers of arithmetic mean to us, but we operate with them confidently enough, because we are familiar with them and know their ways. In the same way, we find that the notion of correspondence between variables stands by us faithfully in one crisis after another. We don't always know where it will come from, but we can be sure that it will be there. Let me give some examples of what I mean.

In elementary algebra we learn to write the equation

$$x^2 - 3x + 2 = (x - 1)(x - 2).$$

The left-hand member of this identity indicates a variable quantity which depends for its value on another variable quantity x. To any particular numerical value of x corresponds a perfectly

definite number $x^2 - 3x + 2$, found by subjecting the number x to the simple arithmetical processes suggested by the formula. We say that $x^2 - 3x + 2$ is a *function* of x. The right-hand member of the identity gives another rule for calculating a second number whenever a value of x is given. The identity states that for any one value of x the associated number given by the first formula will always be the same as the associated number given by the second. These observations, trivial as they are, mean that the algebraic equation expresses the identity of two functions.

Suppose that we undertake to solve the equation $x^2 - 3x + 2 = 0$. It may seem that we are only solving a puzzle, moving the counters in accordance with the rules of the game. But we can attach more meaning to the problem. We have given a function of x; to different values of x correspond different values of the function. With what values of x is the value zero associated? Every problem involving the solution of an equation is a problem involving a functional relation.

The circumference of a circle is $2\pi r$. With a value of the radius is associated a value of the circumference. One is a function of the other. In a given circle, a regular inscribed polygon of n sides has a certain definite perimeter, depending on the value of n. Ordinarily, we do not think particularly of the value of the perimeter as associated with the number of sides of the polygon, we think of it as associated with the polygon itself; and yet a functional dependence of two quantities is really there.

If it requires a special effort to bring in the abstract notion of function in all these cases, why do it at all? The answer is, that the student who has mastered the ideas of number and function holds the whole theory of limits in the hollow of his hand. He may meet with relations that are hard to remember at first, but not with any that are hard to understand. If not altogether simple, they are perfectly clear and definite.

Let us come back to the circle with its inscribed polygons. We remember that as the number of sides of the polygon is indefinitely increased, the ratio of the perimeter of the polygon to the diameter of the circle approaches a limit which we denote by the letter π, and which is approximately 3.14159. What do

we really mean by the statement that the ratio approaches π as a limit? We mean that however good an approximation to the value of π we want, we can be sure of getting it if we only take the number of sides of the polygon large enough. Whatever limit of error we choose to set (I am using the word "limit" *here* in an entirely untechnical sense) we know that all regular inscribed polygons, having more than a certain number of sides, possess in common the property that the ratio of perimeter to diameter is equal to π within the limit of error named. The assertion that a limit is approached is an abbreviation for what I have said at length, for the statement that a certain property is possessed by all regular inscribed polygons with more than a certain number of sides. In the language of a few minutes ago, it means that when the values of the ratio of perimeter to diameter are written down for the various values of n, all the values of the function corresponding to sufficiently large values of n satisfy a certain numerical condition. *It does not mean anything more than this.* The statement can be made more precise than I have made it, but not more comprehensive. It does not mean, for example, that the circle itself is a polygon of infinitely many sides, each of zero length, and that if you add up all these zeros patiently enough, one by one, you will get 3.14159 in some transcendental and supernatural way. The mathematician does not make progress by adding together infinitely many zeros, and as the president of this association has said to me more than once, how can that have infinitely many sides which has not even one?

For another illustration, consider the infinite series

$$1 + \tfrac{1}{2} + \tfrac{1}{4} + \tfrac{1}{8} + \cdots.$$

We say that the sum of the series is 2. Let us inquire how this is to be interpreted. We see that as we take more and more terms of the series, we get sums that are more and more nearly equal to 2. The sum of the first $n+1$ terms is $2 - \frac{1}{2^n}$, a function of n which differs very little from 2 if n is large. The fact that it is never exactly equal to 2, is of secondary importance. The essential thing is, that if any limit of error is assigned, the value of the sum will differ from 2 by less than the amount

specified, for all values of n that are sufficiently large. The function of n with which we are concerned is such that for all values of n beyond a certain point, the corresponding values of the function satisfy a certain numerical requirement. We express this by saying that the sum of the first $n+1$ terms of the series approaches 2 as a limit when n becomes infinite, or, more briefly still, that the series has 2 for its sum. But this does not mean anything more than that the function of n which represents the sum of the first $n+1$ terms has the property already described. It does not mean that by adding together *all* the terms of the series you get the value 2 exactly. I do not object if someone more gifted with poetic imagination than I, and not a student in any of my classes, chooses to refresh himself with such a vision, but I do object with feeling to being told that that is what I mean, or any mathematician with whose ways of thought I am familiar.

I have just one more example to propound. One of the simplest functions of a variable x is the function x^2. Let us consider not merely the associated values of x and x^2 themselves, but the relation between the difference of two values of x and the difference of the corresponding values of x^2. In particular, we will let $x=1$ be one of the values of x, so that we are concerned with the relative magnitudes of the quantities $x-1$ and x^2-1^2. We shall be interested primarily in the relation between these differences when the differences themselves are very small, in other words, when x is very nearly equal to 1. Form the ratio of the two differences; we see that

$$\frac{x^2-1}{x-1}=x+1.$$

This equation has no meaning when x is equal to 1, since it involves division by zero, and division by zero is something that the mathematician does not talk about when he is at work. For values of x that are different from 1, however, and as near to 1 as you like, the equation has a perfectly definite meaning, and shows that the ratio is more and more nearly equal to 2 as the value 1 for x is approached. More specifically, if any limit of error is assigned, the value of the ratio will surely be equal to 2 within this limit of error, if only the difference between x and

1 is sufficiently small. The ratio is a function of x; when x is sufficiently near to 1, the corresponding values of the function all satisfy a certain numerical requirement. In saying that the ratio approaches 2 as a limit, and, in the more technical language of the calculus, that 2 is the value of the derivative of the function x^2 for $x = 1$, we are saying no more than we had said before.

These examples are enough to give color to my claim that the definition of limits is a very matter-of-fact undertaking when the idea of functional dependence is once firmly established. If I have wearied you by repetition, it is because it has been my task to emphasize the fact that the same ideas do appear again and again, in one connection after another. I know perfectly well that nothing that I have said is new, that it has all been better expressed many times before, but I have felt that there is nothing that I could say with more sincerity, in this hour that you have been so kind as to give me, than that I look forward to a time when the belief will be at least tolerated, if not generally accepted, that a mathematician is an honest man who walks on the earth in the light of day.

CONANT HALL,
CAMBRIDGE, MASS.

COLLEGE PREPARATION: WHAT IS ITS EFFECT ON WHAT YOU TEACH AND HOW YOU TEACH IT?

By Amelia C. Wight.

This old world has known many famous teachers. We like to gain inspiration for ourselves sometimes by thinking of them —of Socrates; of Plato, the pupil and intimate friend of Socrates; of Kant, who has been called the modern Socrates; of Dr. Arnold, the great headmaster of Rugby "to whom it was given many to save with himself"; of Edward Thring whose great axiom was "The worse the material, the greater the skill of the worker"; and of many others whom I might mention and of whom you perhaps are thinking as I speak. We also like to think of the great army of men and women whose names we do not know, but who labored faithfully and untiringly in school-room and college-hall and who have quite as clear a title to the promise "They that be teachers shall shine as the brightness of the firmament; and they that turn many to righteousness as the stars forever and ever."

Of them all, however, there was just one perfect teacher and it is an utterance of His I should like to quote this afternoon. He said "Seek ye first the kingdom of God and His righteousness and all these things shall be added unto you." What were these things? Very needful things indeed—what men should eat, what they should drink, wherewithal they should be clothed. Nevertheless this was the command, "Seek ye *first* the kingdom of God and His righteousness."

May I, with all reverence, use this saying to emphasize the principal point I wish to make? A college preparatory class comes to me with the entrance examination or the need for the college certificate in the near future. What shall I do? Seek first the physical, mental and moral welfare of my girls, teach them their geometry and algebra in such fashion as to contribute

the utmost to their intellectual training—and the college preparation will be added.

If a teacher have this attitude toward her work certain results will follow. Of two of these I should like to speak very briefly.

First, the atmosphere of the class-room will be free from all unnecessary strain and stress, the whir and clash of the machinery will be absent, and the pupils will be able to do better work and in quietness to find their strength.

Second, the word "Limits" so often spelled in capitals of the largest size will lose most of its terrors, and the teacher will have courage to "make haste slowly," especially at the beginning. I feel that we can not possibly overestimate the importance of making haste slowly, for many times that is the key to the entire situation. And—we teachers of mathematics have our troubles but we have surely this blessing: if our pupils thoroughly understand their work step by step, they gain in speed as the weeks pass. This is especially true in geometry, for a class completing with difficulty one proposition each period in October can take, with comparatively little effort, two, three or more propositions, depending upon their length and difficulty, during a period in February or March.

Then, too, would it not be wise to trust rather more than we do sometimes to the good judgment of the board of examiners? From our school we have sent many girls to Bryn Mawr College for their entrance examinations and I have grown to feel very confident that the department of mathematics of that college judges the papers largely for their general intelligence. Where that is done, there is surely no occasion for much anxiety because lack of time may necessitate the slighting of the preparation at one or more points.

In connection with the matter of college requirement, however, I feel very strongly that we are doing about all that should be expected of us in the way of preparation. Recently at the Philadelphia High School we were consulted by one of the leading colleges for women with regard to the advisability of including solid geometry among the requirements for admission to college and perhaps lessening slightly the requirement in algebra. While I do believe that logically the place for the solid geometry is the secondary school, nevertheless I hesitate about undertaking anything additional under existing conditions.

I have spoken of the absence of any whir of the machinery in the class-room. May I suggest, however, that definite and careful planning of the work during the year on the part of the teacher and at the end a systematizing of the reviews for the students will materially save their time and strength and help to cover the ground? In the Philadelphia High School for Girls, among other things we do this for our pupils: Just before they take their examinations, we give them a list of examples, fifty or more, selected from one of their text books—examples not especially difficult, but requiring all the principles for which they are responsible. We print the page, the number of the example and the answer; and it has been our experience that even the girls not mathematically inclined are glad to avail themselves of this opportunity to review systematically. I am disposed to think also that success in working out these problems gives them a confidence in themselves that means much when the dreaded day of the examination arrives.

In concluding, may I say that sometimes we all of us feel it to be increasingly difficult to maintain a standard of excellence? We say, and I fear we are right, that children are much indulged in these days and that the almost universal sentiment seems to be against requiring of them any definite or burdensome tasks. Since misery surely loves company, I think I can cheer you somewhat by a quotation from John Locke. He had a number of crude and vicious ideas with regard to the education of children to be sure, but he lived in the seventeenth century, not in the twentieth, and *he* said: "None of the things children are to learn should ever be made a burden to them, or imposed upon them as a task." So the tendency to make life one long holiday for children is evidently not confined strictly to the days in which we are laboring. About once every year, I am in the habit of putting on my board one of the symbols of the School of Pythagoras: "Help men to burden, but not to unburden themselves." I explain its meaning very carefully and, trusting to its having a wholesome effect, I feel myself to be contributing a mite toward counteracting the present tendency to relieve our young people so completely of every burden that they are in danger of losing all sense of responsibility.

Finally, I should like to return to the thought with which I

began by reminding ourseives that one of the points upon which Horace Mann laid special emphasis in his famous "Annual Reports" was this: "The end of education should be the attainment of moral and social personality."

When one of my nephews was a very little child, I offered to give him one day either a silver dollar I happened to have in my purse or a penny. Without a minute's hesitation he chose the penny and his mother said with a smile, "The penny will buy candy, Auntie." Of the possibilities of the dollar in the direction of candy buying he had not the slightest notion. Do we not make a similar mistake when we forget that the silver dollar of education in the best sense of the word includes among other things good and great a *real* preparation for college?

PHILADELPHIA HIGH SCHOOL FOR GIRLS,
PHILADELPHIA, PA.

COLLEGE PREPARATION: WHAT IS ITS EFFECT ON WHAT YOU TEACH AND HOW YOU TEACH IT?

By Harry English.

I have taken the liberty of treating this topic in a somewhat broader way than would appear at first sight to be intended, though it is far from my intention to avoid a direct answer to the obvious meaning. It is hoped however that nothing shall be construed to be other than an unprejudiced presentation of a few salient points for earnest consideration.

College preparation implies a response to college requirements which present in a tangible form the attitude as to prerequisite education and preparedness assumed by the college to be vitally necessary to accomplish the realization of its ideals as to true citizenship, right living and thinking, developed efficiency both individualistic and communistic, intellectual and material achievement, and high moral standards for the citizen unit and the governmental whole.

This attitude may be inflexible, but it is now more or less elastic, responsive partly to local environment, but more largely to country-wide or section-wide sentiments as to economic tendencies and all those agencies which tend to link up the activities of the individual in his home and community with those of the college as a true educational institution to aid the state and the individual to realize the common intellectual, moral social and civic ideals.

These same agencies are affecting most vitally the courses of study, subject matter, methods of instruction, and in fact the whole structure of the elementary schools which are most responsive to home and civic suggestions especially those of various Parent and School Associations which are very active partners in school administration, both elementary and high.

The high school as a continuation of the elementary school must immediately build upon it; as a college preparatory school

it must meet college requirements. The foundation work however is the same, and if it is changed radically and quickly without giving the high school opportunity to adjust itself to the new conditions and continue college preparation, then between the upper and the nether mill stones the high school is sorely pressed to accomplish its dual mission.

Changes in college requirements as to subjects other than mathematics may affect seriously what we teach and how we teach, as such changes frequently necessitate changes in the high-school courses of study, which now that Latin is somewhat suppressed, generally press hard upon the stability of the course in mathematics, not only as to subjects permitted to be taught, but as to methods of teaching. Mathematics, by sheer force of its intrinsic worth, must contend against those new subjects which have a unit value for college entrance, and because of their close association with civic and domestic life appeal forcibly to the pupil as well as the parent, and are capable of being taught in a most attractive and interesting manner with the aid of illustrated lectures, pageants, dramatization of parts of books, plays by the pupils, moving pictures, victrolas, musicals, addresses by prominent men, and kindred stimuli, which are in line with the natural desires of the pupil.

To teach by such methods the sterner realities contained in a worth-while course in mathematics, requiring a constant summing up and application of methods and knowledge acquired, is not possible, if indeed desirable.

They may be desirable adjuncts to the general development of the pupil, but when used to excess are of doubtful ultimate value tending to prevent the formation of the strong backbone of determination, concentration, power of doing and thinking, close and persistent application, and retention of ideas which so characterized the high-school pupil of some fifteen years ago, and which is so lacking at the present time of easy endeavor.

Then there was no such publicity of the sentiment that the sexes are equal in all endeavors, but it was never urged that the girl could not do the mathematics that the boy could. The girl merely took the opportunity to show that she could. Now however it is urged by many that some substitute for algebra and plane geometry must be provided for the girl, since she does

not need them, and that plane geometry be elective for all. This involves a contradiction of hypotheses unless the ultimate aim is to wipe out mathematics entirely. As yet no one has suggested that arithmetic be made elective for either boy or girl, but the suggestion is about due, if the study of arithmetic is disquietingly annoying to the pupil and something better suited to his material interests and natural tendencies can be substituted.

It is evident that high-school methods and topics in mathematics cannot be violently opposed to those of the elementary school, and yet they should adapt themselves to the mentality of the child so as to develop his mental fiber during the wonderfully important period of high-school life, and at the same time must prepare for college, coördinate with other high-school subjects so as not to violate sound principles of child psychology, hold the interest against the more popular and adaptable methods of so-called vital interest, which are more potent to affect methods of teaching mathematics than are college requirements as to stipulated amounts and potentiality.

The path of the teacher and of the pupil in mathematics could be made less hazardous and more attractive and interesting as well as profitable, if an elementary course in so-called observational geometry and mensuration backed up by systematic training in mental arithmetic and followed by a first half-year of algebra were taught in the elementary schools. The discussion as to college requirements in all of its ramifications would then cease, if the present scheme of high-school mathematics is retained, providing that the first two years be required; the last two elective. The field of work would then present any number of possibilities for betterment and mutual aid and at the same time prepare for college.

The first year would complete the required elementary algebra, prepare properly for the problem work of plane geometry by giving the necessary knowledge and power as to handling radicals and quadratics, would help the physics of the second or succeeding years by giving the pupil a knowledge of proportion, and practical measurements, transformation of formulas, an understanding of principles and things and a real power of abstraction. The pupil in the elementary school has the ability to accomplish what is suggested if he is given the opportunity,

and will thereby acquire a power earlier in his school career which will be ready when he needs it most, and without which he is greatly hampered if he goes into the high school, and uncomfortably satisfied if he does not.

The third year could begin with solid geometry, followed by plane trigonometry with direct application to practical surveying with instruments and plotting of surveying problems if desired.

The fourth year could then be used for a review of elementary algebra followed by advanced algebra and a general review of mathematics or a brief course in the elements of conic sections.

Numerous other possibilities suggest themselves.

The present tendency towards a six-year elementary school, followed by a six-year high school will if realized present an admirable solution of present difficulties, if superintendents and high-school principals can be made to see the situation as I see it. If we desire this we should try to accomplish it.

For about thirty years Washington did have such a high-school course in mathematics, preceded by a strong algebra course in the eighth grade. Geometry was always taught from the reasoning standpoint and hundreds of original exercises were worked during each year. Fourth-year pupils easily completed, fifteen years ago, the Cornell requirements in advanced algebra which were far in excess of the present ones, and in addition studied conics, covering the straight line and circle exhaustively and the other conics comparatively, each pupil making a table of analogous formulas.

This formed largely a summary and a review of mathematics.

College requirements did not then affect us either as to scope or methods, but merely prescribed certain topics to be studied by the pupil in order to force him to obtain the knowledge and mental fiber and power necessary for effective progress and development however much he might prefer to slide through by means of a lot of electives (now vastly increased in number) which he merely desired but had no ability to choose.

The four years then were far more productive, with much less wasteful effort on the part of the teacher. The attitude of pupil towards work was more virile. There was no complaint of lack of mentality or ability to do much and do it thoroughly and continuously. There was no sapping of inherent strength.

The reverse is true now though both our teachers and textbooks are supposed to be better.

Now, even the teachers of the new vital-interest subjects seem discouraged as to the mental grasp and attitude of their pupils towards work, and must exert themselves more and more to keep the pupils up to a standard of scholarship which seems to be falling. It would seem that the general tendency towards insisting so much upon developing the pupil, by always keeping in touch with his environment, has not accomplished all that is urged for it and that either the touch is artificial or the environment unreal.

Undoubtedly, forces not well understood are at work to do away with the strength of the old order of things while the external appearance seems to be more effulgent and impressive than before.

There is a panic in the educational world and a run has been started on one of its oldest, greatest and strongest institutions, one which from the very beginning, more than any other, has been the greatest stabilizer of educational currency. Rumors are being circulated as to the soundness of the institution and its methods of administration. It is accused of unrighteous monopolistic tendencies and it is urged that it be closed up. Let the sponsors of this movement, however well-intentioned they may be, pause and think. It may be that the Mathematical Bank, unaided, will finally come down with a crash which will cause such further demoralization as to result in the failure of those new institutions which they are trying to make solid.

It is not at all certain that they are clear as to the real place, actual or relative, in the scheme of education which their specialty occupies, or as to its ultimate effect and influence.

Even the lowly mathematician feels more certain in these respects as to his specialty.

It is undoubtedly true however that though the colleges have modified their requirements by permitting under certain restrictions unit values to certain new subjects, they have, in all of this turmoil of thought, standardized amounts required in various subjects, and thus put a definite stamp of value on educational work, without which the high-school teacher of any subject, left solely to himself, would have been utterly at sea, overwhelmed by the conflict of ideas around him.

For this standardization of educational coins, the high-school teacher should be truly grateful, however he may object to the too little or too much elasticity of circulation permitted.

Co-existent with, if not resultant from, the tendency towards the so-called humanizing of high-school courses and subjects have come a great latitude in the choice of high-school electives and much slower and far less accentuated changes in college courses and requirements.

The changes in requirements have been in subjects as well as in amounts, the latter being lessened actually, or virtually by increasing the number of required high-school periods, the whole being then expressed in terms of units.

The unity of courses became a thing of the past; emphasis was placed upon unit values of unrelated subjects and a tremendous impetus was given to the tendency towards subject promotions. In many cases, unrelated subjects were taken during the last two years in order to make up the number of credits necessary for graduation or college entrance, while at all times it was possible to make up failures of previous years. The disintegration continued until finally, in many cases, there was no longer a class, but a mere composite of the various degrees of intellectuality possessed by pupils of as many as four different school years. Manifestly the method of teaching such aggregations varies greatly from that of teaching a class composed of pupils of the same high-school year with a unity of interest and common endeavor, but this could hardly be attributed either to college requirements or to the scheme used to express them.

The college situation and the high-school situation are both merely responses to the great present-day tendency to treat the pupil as an individual with individual tendencies and not as one of co-ordinate members of the same group; and to minimize to the utmost the class and the institution as such.

Whether this is the wisest policy remains to be seen. The college requirements are surely not to blame; on the contrary, though they may influence what we teach, they are most potent aids to the teachers of high-school mathematics and we would do well to combine forces with our friends in the colleges to consider how best to meet the rising tide of opposition to the continuance of algebra and geometry as required subjects in the

high-school curriculum; an opposition which high-school principals and school superintendents do not seem over enthusiastic to meet. Afterwards we can adjust our differences if any then exist. At present our work is cut out for us and there is no time to waste on non-essentials.

It seems to me quite evident that the general college custom of admitting by certificate leaves the high-school teacher singularly free as to methods of teaching so long as the pupils entering college possess the requisite knowledge, the ability to do and the desire to do, which are demanded by the colleges. Of course there remains the necessity of preparing for the examinations set by the College Entrance Board and by those colleges which do not grant certificate privileges. These examinations are not unreasonable and differ markedly from those set for admission to West Point and Annapolis, which require the special training given by the special coaching schools which prepare for those institutions.

We however are concerned mainly with the question of time and subject limits required by colleges, and it is in the most friendly spirit that I offer the following observations:

I. As to Plane Geometry.

It has always seemed unfortunate to me that the number of recitations per week in this subject was increased from four to five in order to obtain a credit of one unit, with a penalty of reduction in the unit credit for less than five periods per week. This seems to me to put a premium upon the wastage of time, as it was quite possible in the previous years to cover most effectively the entire subject of plane geometry with four periods per week. The added period has resulted either in the introduction of enervating material or a spreading out of the original material over an unnecessary amount of time. In either case the resultant was a greatly impaired efficiency in the use of time not only for plane geometry but for other subjects.

There is too much wastage of time and impaired efficiency in schools as it is and both of these habit-forming educational drugs should be promptly eradicated.

The proper and most effective method of employing time is of

most vital importance in obtaining the best pupil-product and teacher-product, and the scientific study of the most effective use of the recitation period is much needed during these days of boasted scientific, economic and concentrated efficiency. An educational discriminant is needed to get at the root of the matter.

Too much pocket money allowance tends to produce material extravagance; too much time allowance tends to produce educational extravagance.

It may be however that the colleges have recognized that the pupils cannot now do the work in four periods per week, probably because of the intensity of outside distractions, recognized school social life, various societies, athletics, shortening of recitation periods, irregularities of pupils' programs and the many other kindred new developments of recent years. If this is the case the colleges have merely recognized a situation and met it. Otherwise they are somewhat responsible for a lessened high-school educational output, both as to quantity and quality as well as potential efficiency.

Be this as it may there seems to be a vicious circle from which no one seems desirous to escape.

II. As to Algebra.

Some time ago I made a summary of these requirements as set forth in the catalogues of ten colleges representing varied activities. The following observations suggested themselves:

A. Elementary Algebra.

1. The practise of designating one unit for algebra to quadratics, and one half unit for quadratics and beyond is not uniform. In some cases 1½ units are designated for elementary algebra, though the sum total of topics required is not coextensive with the combined total as separately expressed by other colleges. In one case one half unit is given for a group of topics, composed of topics selected from those usually given under elementary algebra, and additional topics.

2. Although in the main the designations of various topics were practically the same, the differences were sufficient to admit of different interpretations.

3. Numerous particular things insisted upon by some colleges are omitted or taken for granted by others.

In other cases the differences were specially emphasized or broad topics given without particularizations.

I give some examples:

(*a*) H. C. F. by factoring only and solution of equations by factoring (no L. C. M.) *or* H. C. F. and L. C. M. unqualified *or* H. C. F. and L. C. M. by factoring.

(*b*) Linear equations unqualified; omitted; with particularizations.

(*c*) Extraction of roots unqualified; square root only, equations involving radicals; extraction of roots particularized.

(*d*) Quadratics unqualified; quadratics particularized.

(*e*) Problems depending on; omitted.

(*f*) Progressions qualified; unqualified.

(*g*) Binomial theorem, proof omitted; binomial theorem unqualified.

(*h*) Graphic method (one college only).

(*i*) Negative quantities and interpreting negative results (one college only).

(*k*) Concrete examples from physics, commercial life (two colleges).

(*l*) Other similar cases.

B. Advanced Algebra.

1. Same designations are not used to denote same topics.

2. One college requires a number of topics not required by any other and omits some not required by them.

3. A second college requires a number of topics not required by any other and omits all required by the others.

4. One college requires simple problems of choice and chance, others require simple cases of permutations and combinations, or merely permutations and combinations.

5. One college at least requires graphical representation of division and multiplication of complex numbers.

6. One college specifies omission of multiplication theorem in determinants. Others are silent.

7. One college requires theory of equations unqualified. Others go into details more or less specific.

8. Many colleges expressly require various specific things not of a topical nature.

Conclusions.

1. It would seem advisable for all colleges to agree to use the same language or term to designate the same thing and if possible to agree upon the same set of topics classified under exactly the same main divisions of elementary algebra and advanced algebra.

2. Special diverging desires as to ability and particular features of algebraic work could be more simply expressed and the method of expression so standardized as not to lead the pupil to feel that various colleges want various kinds of mathematical ability, because of different language employed. This standardization of requirements as far as possible into identical language statements would remove much petty annoyance, as fundamentally for the most part colleges desire the same thing.

3. *As to Advanced Algebra.*—The minimum requirements present a set of somewhat detached fragmentary elements very difficult to teach developmentally. Many topics have been omitted that were in previous requirements and which would seem to be necessary for college work and which at the same time would furnish links to a broad knowledge of the power of algebraic thought and would permit of a sustained method of teaching and the acquisition of a power of conclusive action thereafter. Advanced algebra at its best seems to be a training in the use of tools, but the process of training could be a more coherent and sequential one. Again it is urged that a standardization of topic designations and topics selected be made, as it is part of our duty in Washington to provide for many colleges, and between them all, they stretch over a vast territory in advanced algebra. Here only are we greatly affected as to methods and topics.

Washington occupies a unique position. It is legislated for by the Congress of the United States, even to minute details.

Indeed there is a congressional provision, which so far as I know has never been repealed which is to the effect that the Washington high schools shall provide instruction sufficient to prepare for admission to Harvard College.

Our high schools are also unique in that they have a population of the most diversified kind which may be divided roughly into two groups:

(*a*) *The Fluctuating:* Composed of children of Senators, Representatives, army and navy officers, government officials, foreigners connected with the diplomatic corps, and other temporary residents.

(*b*) *The Permanent:* Composed of children of government clerks, business men, and other permanent residents.

The high schools of Washington have a population proportionally as large as that of any other city. The same is true of our graduates who enter college and the number of different colleges entered is very great.

Usually a city high school prepares mainly for some one college. Our graduates in the main either have very recently come to our high schools from other cities or are children of parents who have come to us in former years and naturally are to go to those colleges in which the parents are more or less interested. It is most difficult to provide suitable high-school instruction for those who come to us in all stages of preparedness as high schools differ materially in arrangement of courses and traditions.

It is still more difficult to prepare for numerous different colleges, if they differ even slightly in requirements. Heretofore this matter has been adjusted without much hardship. However, three years ago, after a continuance of thirty years, algebra was dropped from the eighth grades and immediately there arose the serious problem of radically readjusting the high-school course in mathematics. At present it seems that the course must be much twisted because of the pressure which presumably forced algebra out of the eighth grades and presumably is due to the desire to prepare for life by adjustment to environment as viewed by the scientific social worker and those who have special views as to the co-ordination of home, school and city life.

This crisis comes at a time when we must prepare for many more colleges than is usually the case, and is made more acute because with few exceptions our high-school classes are mixed classes. Confronted by the growing tendency to make geometry

and algebra elective for girls and it may be, geometry elective for boys, the prospect of readjusting our course is not inviting, and any stabilizing of the requirements in algebra, especially advanced algebra, will be gladly welcomed by the Washington high-school teacher of mathematics. For the first time we are seriously troubled as to what to teach and how to teach, but college preparation as responsive to college requirements is merely incidental. The difficulties, ever increasing, are of a different character, and it behooves us all to come to the defense of the educational right of mathematics to live and fulfill its manifest destiny as the rock foundation of educational truths and endeavors.

WASHINGTON, D. C.

REPORT OF THE GEOMETRY COMMITTEE.

At the Pittsburgh meeting of this association this committee presented a preliminary report which outlined a plan of procedure. That report was approved at that meeting and published in the December, 1913, issue of the MATHEMATICS TEACHER. In that report the committee said that one of the first tasks which it had undertaken was that of preparing a suitable non-geometrical test to determine the results of geometry teaching as to reasoning ability, and in the report the committee gave five questions indicating in a general way the nature of the questions that should constitute such tests.

A request was made for the members of the association to send to the committee questions of a non-geometrical character which could be given to high school students. A few members of the association responded. From the questions thus gathered together a test was prepared, and that test has been given to several groups of students, and to two groups of teachers.

In a paper presented by the chairman of the committee at the meeting of the association in February, 1914, the list of questions composing this test was given. That paper was published in the MATHEMATICS TEACHER for March, 1915. It also contained the results obtained by giving the test to a group of high school girls. Following that, Professor C. E. Rogers, now of the East Tennessee State Normal School, Johnson City, Tennessee, gave the same set or a slightly modified set to five groups of students. Also Professor Leonard M. Passano gave the same set of questions to two groups of students in the Massachusetts Institute of Technology, and Professor Sarah E. Smith gave the set to two groups in Mt. Holyoke College. Professor Rogers compiled the results of the test given by him and they were published in the December, 1915, issue of the MATHEMATICS TEACHER. Professor Passano compiled the results of the test given by himself and those given by Professor Smith and they also were published in the same issue.

For future reference I have numbered these various groups as follows:

1. Forty-four high school girls to whom the test was given by the chairman of the committee. This whole group had covered the first two books of plane geometry, and had also studied constructive geometry for one quarter of a year. The coefficient of correlation between the results of this test and their marks in plane geometry is .50 with a probable error of .08. It was a fairly homogeneous group, and consequently one would expect the frequency curve for measurements of reasoning ability to be approximately normal. The chairman also computed the coefficient of correlation between the results of this test and the marks obtained in English. In this computation the English marks were not available for two of the students. The coefficient of correlation thus obtained is .32 with P.E. of .10.

2. Thirty-eight girls in the Horace Mann School to whom the test was given by Professor Rogers. All the students in this group had completed the usual amount of plane geometry, and all were in the fourth grade of high school. Consequently this group was also fairly homogeneous. The coefficient of correlation with their geometry marks is .75 with P.E. of .05.

3. Eighty-four girls in the Washington Irving High School to whom the test was given by Professor Rogers. All the students in this group were studying Book V in plane geometry at the time the test was given, and all were in the third year of high school, so that this group also was fairly homogeneous. The coefficient of correlation with their geometry marks is .31 with P.E. of .07.

4. Twenty-nine girls in the Horace Mann School to whom the test was given by Professor Rogers. They were for the most part third-year high school students and the amount of time previously spent in plane geometry varied from one quarter of a year to a whole year. This group, as far as the study of plane geometry was concerned, was not nearly so homogeneous. The coefficient of correlation with the geometry marks is .25 with P.E. of .12.

5. Thirty-eight young ladies and gentlemen in the East Tennessee State Normal School to whom the test was given by Professor Rogers. Their classification corresponded approximately

to the fourth year high school grade, but their average age was a little over twenty, that is, appreciably higher than the average age for fourth year high school pupils. Practically all of them had completed plane geometry within a year. The coefficient of correlation with their class marks is .52 with a P.E. of .12.

6. Forty-eight mathematics teachers in attendance at the joint meeting of the New England Association and the Association of the Middle States and Maryland, February 28, 1914, to whom the test was given by the chairman of this committee.

7. Twenty-four young ladies and gentlemen in Teachers College. These students were all of the maturity of ordinary college students, and at the time the test was given were taking a course in Teachers College in the nature of a practicum in the teaching of mathematics. It was not feasible to obtain the data for the computation of the coefficient of correlation with the geometry marks.

8. Thirty-three freshmen in the Massachusetts Institute of Technology to whom the test was given by Professor Leonard M. Passano. This test was given when they had nearly completed the work of the freshman year. The mathematics of the freshman year there includes plane and solid analytical geometry and differential calculus.

9. Thirty-two sophomores in the Massachusetts Institute of Technology to whom the test was given by Professor Passano. The test was given near the end of the sophomore year during which they had studied elementary calculus and elementary differential equations.

10. Twenty sophomores in Mount Holyoke College. Previous to this test they had had a half year of analytical geometry and a half year of calculus.

11. Twenty-one juniors in Mount Holyoke College. They had had an additional year's work in calculus.

No coefficient of correlation was obtained for either of the groups in the Massachusetts Institute of Technology nor for either of the groups in Mount Holyoke College.

The following table (Table I) gives the percentages of the various groups making the different possible scores. The numbers at the top of the columns give the number of points scored.

In the case of groups 2, 3, 6, 8, 9, 10 and 11 the set of ques-

TABLE I.

No. of Group.	0	1	2	3	4	5	6	7	8	9	10	11
1	0	2	5	23	11	25	25	7	2	0		
2	0	0	5½	2½	24	10	24	18	13	3		
3	0	2½	6	14½	15	36	19	7	0	0		
4	3½	3½	14	21	34	10	7	7	0			
5	0	0	0	5	0	15	14	8	21	27	5	5
6	0	0	0	0	6	4	12½	15	25	37½		
7	0	0	0	4	8	17	25	8	38			
8	0	0	3	0	3	12	24	9	30	18		
9	0	0	0	0	6	9	9	19	34	22		
10	0	0	0	0	5	0	15	30	35	15		
11	0	0	5	0	0	5	5	19	33	33		

tions given was identical with that given by the chairman of the committee in the paper published in the MATHEMATICS TEACHER of March, 1915, and reprinted in the paper of Professor Passano in the MATHEMATICS TEACHER of December, 1915, and also reprinted in the paper of Professor Rogers in the last mentioned issue.

In the case of groups 4 and 7, question II (4) was inadvertently omitted, and in the case of group 5 Professor Rogers added two additional questions. In the case of groups 4 and 7 the maximum possible score was eight points, and in the case of group 5 the maximum score was eleven points. In the case of the other groups the maximum score was nine points.

The following table (Table II) gives the percentages of each group scoring on the different questions. The numbers at the top of the columns are the numbers associated with the questions in the chairman's paper in the MATHEMATICS TEACHER of March, 1915.

TABLE II.

No. of Group	I.	II(1).	II(2).	II(3).	II(4).	III.	IV(1).	IV(2).	V.	VI.	VII.
1	70.0	50.0	84.0	73.0	64.0	14.0	11.0	84.0	16.0		
2	82.0	57.0	89.0	55.0	84.0	42.0	34.0	87.0	37.0		
3	58.0	65.0	93.0	66.0	59.0	23.0	11.0	74.0	17.0		
4	67.0	42.0	73.0	55.0		17.0	7.0	83.0	31.0		
5	82.0	84.0	89.0	76.0	89.0	29.0	11.0	79.0	42.0	68	55
6	94.0	98.0	100.0	96.0	96.0	73.0	75.0	71.0	58.0		
7	83.0	62.0	83.0	67.0		67.0	83.0	83.0	71.0		
8	93.9	66.7	100.0	72.7	81.8	39.4	90.9	87.9	60.6		
9	87.5	90.6	100.0	90.6	84.4	31.2	93.7	87.5	65.6		
10	95.0	80.0	100.0	75.0	100.0	60.0	80.0	95.0	50.0		
11	100.0	90.5	95 2	81.0	95.2	52.4	81.0	85.7	81.0		

A study of Table I shows that the distribution was approximately normal for those groups that consisted of students of the usual high school age and maturity. Moreover, in each of those cases there is a fairly good-sized coefficient of correlation between the results of this test and the geometry marks. In cases of more mature students the distribution is very much skewed towards the large scores.

Up to the present time the purpose has been to determine the reliability of this test as a measure of reasoning ability.

The committee believes the above data to show that the test is fairly reliable, but it believes, nevertheless, that it can be improved.

Table II shows that questions III, IV (1) and V were the most difficult. Professor Rogers has called attention to this fact and has suggested substitutes for III and IV (1).

The committee believes the acceptance of Professor Roger's substitutes will improve the test.

At least three possible lines of action are now open from which to make a choice:

1. Proceed now to give this amended test to a large number of persons as explained in the committee's first report, and then analyze the results.

2. Make further efforts to improve the test and make more trials as to its reliability, before using the test as explained in the committee's first report.

3. Abandon the plans of the committee as given in the first report.

The committee believes that the choosing of the next line of action is so important that it should be given consideration by a body more representative of the whole membership of the Association than this small committee and therefore recommends that the Council review the reports of this committee and determine upon the next line of action.

GEO. GAILEY CHAMBERS,
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UNIVERSITY OF PENNSYLVANIA.

THE ASSOCIATION OF TEACHERS OF MATHEMATICS IN NEW ENGLAND.

Final Report of the Committee on the Mathematics of the Pre-High School Grades.

In submitting the final report of the committee appointed by the council of this association in May, 1914, "To investigate the mathematical program of the grammar grades throughout New England," we desire to call to your attention the conclusions as stated in our first report which was presented before this Association in May, 1915.

They are stated therein as follows:

1. That, while there has been a tendency during the last decade to eliminate certain obsolete topics and to simplify the treatment of certain others retained, there is still a need in certain sections of New England, (1) to eliminate topics like the following: troy weight, apothecaries' weight, surveyors' measure, longitude and time, present worth, exchange, compound and partitive proportion, compound partnership, average of payments, problems dealing with the indirect cases of interest, cube root, and the mensuration of frustums, (2) to curtail and simplify the treatment of interest—especially annual and compound, partial payments, bank discount, stocks and bonds, taxes, and insurance.

2. That in connection with the treatment of the two major topics in these grades, viz., percentage and mensuration, there is an excellent opportunity and a need to make the arithmetic work real and vital.

In the case of the former topic (percentage) by a presentation made more simple, exact, and definite by the use of concrete materials such as: list prices of articles bought and sold, sales' slips, industrial reports, bank checks, notes, etc., and by having the pupils devise, propose, and solve simple practical problems dealing with these materials and situations thus objectified.

In the case of the latter topic (mensuration) by emphasizing drawing to a scale, the matter of approximating results, and the

meaning of such approximations with respect to the degree of accuracy attainable with the data used.

3. That there is real need for emphasizing oral or mental arithmetic in these grades. Such oral work not to be limited to the field of pure number work alone but to include problem work as well.

4. That in these grades the aim should be not merely for a mastery of the mechanics of arithmetic but for the attainment of some degree of skill in calculating. By skill is meant the ability to get a correct numerical result in the most economical way and to be able to check it approximately or definitely as the conditions may permit.

5. That there is little sentiment among teachers of the eighth grade favoring the introduction of work of an algebraic nature in that grade but that many desire a program providing a minimum amount of arithmetic for all pupils and some additional topics for the most capable pupils.

Since the presentation of our first report, sub-committees, consisting largely of grammar school teachers especially interested in arithmetic, have been at work in Springfield, Worcester, and Boston, under the leadership of individual members of this committee, criticizing and revising the program of mathematics for grades 7 and 8 which was formulated on the basis of the above conclusions.

All of the above conclusions this committee again endorses and submits for your consideration and adoption the conclusions as stated with the following program of mathematics for grades 7 and 8 as they are now generally constituted throughout New England.

Material 1. Problems employing assigned numbers.

2. Problems employing numbers obtained by measuring.

3. Percentage work—concrete materials such as: list prices, sales' slips, industrial reports, local and city budgets, bank checks, notes, etc.

4. Simple numerical equations involving (*a*) division and (*b*) multiplication leading to the statements of the work and results in equational form, *e. g.*,

   a. If oranges are sold at 36 cents per dozen, find the cost of one orange.

   b. If one quarter of a pound of tea costs 25 cents, find the cost of one pound.

Solutions:

a. $12x = 36$

$x = 1/12$ of 36, etc.

b. $x/4 = 25$.

$x = 4 \times 25$, etc.

OUTLINE.

Seventh Grade.

1. Fundamentals of percentage.
   - *a.* The per cent idea as,
     - (1) A rate per hundred.
     - (2) A number of hundredths.
   - *b.* The ratio of numbers expressed as per cents with simple problems of application.
     - (1) Games and scores.
     - (2) School data.
     - (3) City and governmental reports.
     - (4) Gain and loss per cents in business transactions.
   - *c.* Finding per cents of numbers with simple problems of application.
     - (1) Games and scores.
     - (2) School data.
     - (3) City and governmental reports.
     - (4) Single discounts in the business world.
     - (5) Commissions on a percentage basis.
     - (6) Simple Interest.
2. The simple equation.
   - *a.* Axioms.
     - (1) Division.
     - (2) Multiplication.

     Note: Work to be introduced by problems which require for their solution one or both of the above axioms.
   - *b.* Applications.
     - (1) Percentage formula, *i. e.*, $p = b \times r$.

Eighth Grade.

1. Extended applications of percentage.
   - *a.* Buying and selling.
     - (1) Store problems.
       - (*a*) Single discounts reviewed.
       - (*b*) Successive discounts.
     - (2) Commission.
       - (*a*) Percentage basis.
         - (1) General business.
         - (2) Brokerage.
         - (3) Real estate.
       - (*b*) Number basis.
         - (1) General business.
         - (2) Brokerage.
   - *b.* Compound interest as related to personal accounts in Savings Banks.
   - *c.* Partial payments as related to mortgages and purchases on the instalment plan.
   - *d.* Taxes.

     (Local applications to city budgets, etc.)
   - *e.* Insurance as related to homes.

2. Indirect problems in percentage.
   - *a.* General formula, *i. e.*, $b = p/r$.
   - *b.* Marking goods.
     - (1) Where per cent gain is reckoned on receipts.
     - (2) Providing for discounts.
     - (3) Providing for anticipated losses.

(2) Simple interest formula, *i. e.*,

$$i = p \times r \times t.$$

3. Mensuration.
   a. Measurement and relation of lengths and distances. (Use foot rule.)
      (1) Number field.
         (*a*) Numbers assigned.
         (*b*) Numbers obtained by counting.
         (*c*) Numbers obtained by measuring.

      Note: Distinction made between degree of accuracy obtainable and that desired for a given practical purpose.
   b. Measurement and ratio of angles with application to slopes and grades, intersections of streets, etc. (Use protractor.)
   c. Perimeters of plane figures.
      (1) Square, rectangle, parallelogram, triangle, trapezoid, and circle.
      (2) Application and use of formulas.
   d. Areas of plane figures.
      (1) Square, rectangle, parallelogram, and triangle.
      (2) Application and use of formulas.

3. Mensuration.
   a. Area of trapezoid and circle.
   b. Surface and volume of: cube, rectangular block, prism, and cylinder.
   c. Problems of application.
4. Ratio and simple proportion.
   a. Proportion expressed as an equality of two fractions.
5. Thorough reviews — oral and written—on the fundamentals of arithmetic.

Note.—The field of applications of mensurational work should be enlarged by the use of hectographed figures the dimensions of which are to be determined by the pupil by measurement.

It has been our purpose, as stated in our first report, to investigate and summarize the opinions of representative teachers of mathematics in the grammar grades throughout New England as to *content* and *method* in the mathematics work of these grades. It is on this basis that the above program is submitted.

In conclusion we may state that the teachers of mathematics in the grammar grades believe, (1) that nothing will be gained in

the mathematics work of these grades by teaching formal algebra as such, (2) that the presentation and treatment of the topics included in this outline should be simple, exact and definite, (3) that pupils should be led to depend upon their own reasoning powers, (4) that oral work should have a place in every recitation, (5) that in written work of a mechanical nature an effort should be made to develop real mathematical calculation and that in applied work pupils should be taught and held responsible for simple schematic ways of arranging the work so that it can be easily reviewed, (6) that the topics included herein while providing a minimum amount of work for all pupils will also provide by extended applications a maximum amount for the most capable pupils.

This committee desires to acknowledge its indebtedness to the many teachers of the grammar grades throughout New England—especially in Springfield, Worcester, and Boston—who in committee meetings and in other ways, have given generously of their time and thought to the consideration and discussion of the Program herewith presented.

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In the discussion by members of the association of the motion that "the report of the committee on the mathematics of the pre-high school grades be accepted and the committee discharged with the thanks of the association," it was the desire of the association to append with its endorsement the following suggestions of improved methods to be recommended to the teachers of mathematics in these grades:

1. That in mensuration, a foot-rule giving two scales on the opposite edges of the same stick be used—the one scale showing the foot subdivided into tenths and hundredths, the other showing the usual subdivisions—so that the field of applied work in decimal fractions may be materially enlarged and sensible approximations in computations duly emphasized.

2. That in the seventh grade, multiplication in which the figures of the multiplier are used in the reverse order from that of the present be taught in order that the pupil may come naturally to approximate his final product at the outset. It is the hope of this association that this method may soon be the only method of multiplication presented in the grades.

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NEW BOOKS.

Lectures on Ten British Mathematicians of the Nineteenth Century. By ALEXANDER MACFARLANE. New York: John Wiley & Sons. Pp. 148. $1.25 net.

This is number 17 of the series of *Mathematical Monographs* issued by these publishers and contains an account of the leading British mathematicians of the last century. The names included are Peacock, De Morgan, William Rowan Hamilton, Boole, Cayley, Clifford, Smith, Sylvester, Kirkman, Todhunter. The sketches given are very interesting and instructive and the volume is in the usual attractive form of the series.

Euclid's Book on Divisions of Figures. By R. C. ARCHIBALD. Cambridge: The University Press; G. P. Putnam's Sons, American representatives. Pp. 88. $1.50.

In 1851 Woepcke discovered in Paris an Arabic manuscript of Euclid's work "On Divisions" and translated it into French. Professor Archibald in this volume has given a restoration of this work of Euclid based on the Woepcke translation and on the geometry of Leonardo Pisano. The English-speaking student of mathematics is greatly indebted to the author and publishers for this scholarly piece of work in splendid form.

Scientific Papers. By SIR GEORGE HOWARD DARWIN. Volume V. Cambridge: The University Press; G. P. Putnam's Sons, American representatives. Pp. 81. $1.75.

This supplementary volume of Darwin's Papers contains his lectures on Hill's lunar theory and biographical sketches by Sir Francis Darwin and Professor E. W. Brown.

The lectures explain the essential peculiarities of Hill's work and the sketches give a view of Darwin from two angles.

Analytic Geometry. By W. A. WILSON and J. I. TRACEY. Boston: D. C. Heath and Company. Pp. 212. $1.20.

The aim of the authors has been to present that part of analytical geometry essential for calculus and is so arranged that less important topics may, if desired, be omitted and both the analytical geometry and the calculus covered in one year. The book seems to be well adapted for the purpose intended.

Education Through Play. By HENRY S. CURTIS. New York: The Macmillan Company. Pp. 359.

The place of play in education is receiving much more attention to-day than formerly, and teachers must appreciate its importance and make more use of it now than before.

The author of this book treats with clearness and breadth the subject from the standpoint of physical, mental and moral development, and shows the part it should play in the curriculum of our schools.

A History of the Family as a Social and Educational Institution. By WILLYSTINE GOODSELL. New York: The Macmillan Company. Pp. 588.

Every student of general education, and that should include every teacher, in order to get a comprehensive view of the development of the subject must trace the history of the family from early times. The author of this volume has made a very comprehensive study and has produced a splendid work from the standpoint of both sociology and education.

An Introduction to the Use of Generalized Coördinates in Mechanics and Physics. By W. E. BYERLY. Boston: Ginn and Company. Pp. 118. $1.25.

This book consists of five chapters of which the first is an introduction giving some applications to problems involving the dynamics of particles and of rigid bodies. Chapter II is on The Hamiltonian Equations, Routh's Modified Lagrangian Expression, and Ignoration of Coördinates. Chapter III treats of Impulsive Forces, and IV of Conservative Forces. Chapter V gives applications to Physics. An appendix giving a syllabus on Dynamics of a Rigid Body and another on the Calculus of Variations concludes the work.

Democracy and Education. By JOHN DEWEY. New York: The Macmillan Co. Pp. 434. $1.40.

This book is an introduction to the philosophy of education. A philosophy which connects the growth of democracy with the development of the scientific method and points out the changes necessary in both subject matter and method to accomplish the best developments.

Professor Dewey is an original thinker and has given in this volume a good contribution to the philosophy of education.

Teaching of History in Elementary and Secondary Schools. By HENRY JOHNSON. New York: The Macmillan Co. Pp. 497.

The greater portion of this volume is devoted to a discussion of underlying principles and their applications to the problems of history teaching in this country. The author believes that boys and girls properly taught can enjoy and profit by the study of history and he gives suggested exercises which his experience has dictated to bring the desired results.

First Year Mathematics. By GEORGE W. EVANS and JOHN H. MARSH. New York: Charles E. Merrill Co. Pp. 353. Price 90 cents.

This is one of the most consistent of the books written around the equation as a center and introducing problem material from the other subjects of mathematics. It reduces abstract manipulation to a minimum, and emphasizes the application of algebraic processes to the solution of problems to a very unusual degree.

The chapter on approximate computation is timely and is well written.

The book gives every evidence of careful study and experiment on the part of its authors, and deserves examination by teachers.

Industrial Arithmetic. By NELSON L. RORAY. Philadelphia: P. Blakiston's Son and Co. Pp. 154. Price 75 cents.

This book contains a course in arithmetic suited to the first year of industrial high schools. Its problems are such as boys are required to handle in the various kinds of shop work, and they include all of the principal geometric applications to such work.

This book should fill a need in schools of this type.

Trigonometric and Logarithmic Tables. By GEORGE WENTWORTH and DAVID EUGENE SMITH. Boston: Ginn and Company. Pp. 104. Price 60 cents.

An excellent set of five-place tables, well arranged to avoid eye strain and in convenient form. The angle tables are given in minutes, but a conversion table for decimal parts of a degree makes it possible to use either method of dividing an angle.

A Community Arithmetic. By BRENELLE HUNT. New York: American Book Company. Pp. 277.

This book is intended for use in the upper grades or in the junior high school. It applies the methods of arithmetic to community needs, and covers the common applications of arithmetic quite thoroughly. Typical chapters are "Making Change," "Grocery Problems," "Meat Market Problems," "Industrial Problems," "Railroad Freight Problems," "Carpentry Problems," "The Hardware Business," "A Practical Study of Lumber," "Taxes," "Postal Problems" and "Saving and Investing Money."

Intermediate Algebra. By H. E. SLAUGHT and N. J. LENNES. Boston: Allyn and Bacon. Pp. 249.

This is a continuation of the elementary algebra by the same authors, and follows the same general methods as the earlier book. It contains an excellent chapter on the use of determinants in solving equations, and one on the use of logarithms. The book covers the usual requirements in intermediate algebra, and seems to be well written and teachable.

General Science. By LEWIS ELHUFF. Boston: D. C. Heath and Co. Pp. 433.

The author says that "This book is intended to offer a scientific explanation for the many and varied experiences which pupils of high school age have had and to create a desire for further knowledge of scientific subjects." It seems well fitted to do both of these things, as it covers quite thoroughly the daily experiences that have a scientific foundation, and does it in an interesting way. An excellent feature is the emphasis placed on health and preventive methods.

The Automobilist's Pocket Companion and Expense Record. Arranged by VICTOR W. PAGÉ, M.S.A.E. New York City: The Norman W. Henley Publishing Co. Pp. 169. $1.00.

This book is not only valuable as a convenient cost record but contains much information of value to motorists. Includes a condensed digest of auto laws of all States, a lubrication schedule, hints for care of storage battery and care of tires, location of road troubles in all parts of the car, anti-freezing solutions, horse-power table, driving hints and many useful tables and recipes of interest to all motorists. Not a technical book in any sense of the word, just a collection of practical facts in simple language for the everyday motorist.

It will enable you to keep track of all your expenses. Convenient ruled pages eliminate all bookkeeping except entering a few figures daily. Shows the miles covered during each day of the year, the fuel used and cost of repairs. Tells if your tires are standing up to their guarantee, which make of tire gives best service, etc.

It answers questions that every motorist asks about car driving or care. If you have an automobile you will want one. Convenient pocket size, handsomely bound in limp leatherette cover.

The Principles of Health-Control. By F. M. WALTERS. Boston: D. C. Heath and Company. Pp. 476. $—.

This book differs from the usual work on hygiene chiefly in the emphasis that is placed upon corrective work.

It will be found useful not only as a text for classes but for individuals who desire to conserve their health and be more effective in their work.

NOTES AND NEWS

THE Annual Meeting of the *Association of Teachers in the Middle States and Maryland* will be held in Baltimore the Saturday following Thanksgiving Day:

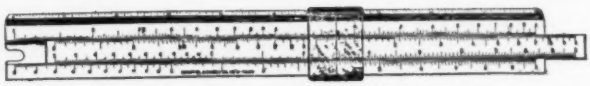
Browning at Seventy

I find earth not gray but rosy;
Heaven not grim, but fair of hue.
Do I stoop? I pluck a posy;
Do I stand and stare? All's blue.

John Burroughs at Seventy-five

Away with clocks and sun-dials. Time and I
Have made a compact,—this to be my boon,—
To hear the evening thrush, and know the hour,
Yet feel it noon.

K&E SLIDE RULES



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THE AMERICAN ASSOCIATION to Promote the Teaching of Speech to the Deaf is authorized to pay $300 of the income from the Alexander Graham Bell Grosvenor Memorial Fund for the best essay on the above subject received on or before twelve o'clock noon on November 1, 1916. The award will be made by the board of directors.

Each essay submitted shall consist of from 20,000 to 21,000 words. Three typewritten copies of the essay shall be prepared, each bearing a distinguishing mark or *nom de plume,* but nothing to tell who the writer is; the three copies shall not be folded, but sealed in a plain flat envelope, bearing only the title of the essay and the distinguishing mark or *nom de plume* of the writer. Then the name and address of the writer with the mark or assumed name shall be typewritten on a card or sheet of paper and sealed in a small envelope. These two envelopes shall then be

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sealed in a third envelope, bearing no indication of who the sender is, and addressed to "The Judges of the Alexander Graham Bell Grosvenor Memorial Fund, Volta Bureau, 1601 35th Street, Washington, D. C." The essays should be mailed or expressed or otherwise sent so as to reach the Volta Bureau during the last week in October and not later than noon of November 1, 1916. The judges selected to pass upon the merits of essays are: Mr. and Mrs. Edmund Lyon, Rochester, N. Y.; Mr. and Mrs. A. L. E. Crouter, Mt. Airy, Philadelphia, Pa.; Mr. and Mrs. Gilbert H. Grosvenor, Washington, D. C. The judges will report their findings to the board of directors, who reserve the right to withhold awarding the prize should the judges report that none of the essays possessed sufficient merit to warrant an award. The essay awarded the prize becomes the property of the American Association to Promote the Teaching of Speech to the Deaf, and will be published in the *The Volta Review* and later in book form.

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